Simulation Studies on Formation of Earth's Radiation Belt and Ring Current

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Theory and observation of electromagnetic ion cyclotron triggered emissions

Electromagnetic ion cyclotron (EMIC) waves are suggested to play a significant role in the dynamics of the Earth's radiation belt and the ring current. We develop a nonlinear wave growth theory of EMIC triggered emissions observed in the Earth's magnetosphere. After deriving the basic wave equations from Maxwell's equations and the momentum equations for the electrons and ions, we obtain equations that describe the nonlinear dynamics of resonant protons interacting with an EMIC wave. The frequency sweep rate of the wave plays an important role in forming the resonant current that controls the wave growth. Assuming an optimum condition for the maximum growth rate as an absolute instability at the magnetic equator and a self-sustaining growth condition for the wave propagating from the magnetic equator, we obtain a set of ordinary differential equations that describe the nonlinear evolution of a rising tone emission generated at the magnetic equator. Using the physical parameters inferred from observations by the Cluster spacecraft, we determine the dispersion relation for the EMIC waves. Assuming saturation of the wave amplitude, as is found in the observations, we find good agreement between the numerical solutions and the wave spectrum of the EMIC triggered emissions. [1]

Microburst precipitation of energetic electrons

Energetic electrons are often observed to precipitate into the Earth's atmosphere with a short duration (<1 sec). This is called an electron microburst, which comprises an important loss process from the outer radiation belt. By means of a self‐consistent full‐particle simulation, we show that microburst precipitation of electrons with energies ranging between 10 keV and 100 keV accompanies the generation of discrete bursty chorus wave emissions. We demonstrate a one‐to‐one correspondence between the electron microbursts and the generation of discrete chorus elements. This simulation study is the first to establish such an exact correlation between electron microbursts and the generation of chorus elements. [2]

Rapid recovery of storm-time ring current

The Earth's ring current sometimes exhibits rapid decay, but the underlying mechanism was unknown. We perform a simulation of energetic ions that constitute the ring current. When we include the field line curvature (FLC) scattering of the ions, the ring current shows rapid recovery with an e-folding time of ~6 h, which is consistent with observations. However, without FLC scattering, the ring current shows a slower recovery with an e-folding time of ~12 h. Energetic neutral hydrogen with energy ≥ 39 keV is significantly reduced by the FLC scattering, which is consistent with data from the IMAGE satellite. Power of precipitating protons also shows a fairly good agreement with data from IMAGE. We conclude that the FLC scattering is a significant loss mechanism for the ring current. [3]

References

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